Safe Fissile Material Spacing In Water

A number of infinite arrays of subcritical units in water were studied[1] to determine the change in the array k-effective, k_a, with the change in the water spacing between units. Calculations were made with the DTF4, GEM 4 and KENO codes and with plutonium solution and reactor fuel element units. The data was then used to develop a method of determining a safe spacing with a minimum of computer usage.

The k_a values were determined at various water spacings for a number of representative units. The resulting data was then normalized to 1.0 at zero water spacing (equal to k_∞ for the material of the units) and to 0.0 at infinite water spacing (equal to the isolated unit k-effective, k_u) by the equation $(k_a-k_u)/(k_\infty-k_u)$. A limiting curve was then drawn which encloses all the calculated curves (see graph V.D.2-2) and which permitted the selection of a safe water spacing if k_∞ and k_u are known and a safe value of k_a is selected. Although these safe spacings are not as small as could be determined by a direct calculation they are much less limiting than the spacing required for the complete isolation of each unit and a number of cases may be looked at before selecting a final case for a more definitive calculation.

The limiting curve may be used with a given k_a value to develop a family of curves as shown in V.D.2-3, for more general studies.

It should be recognized that the "limiting curve" is actually applicable only for the types of material studied (e.g., 0.5-inch diameter UO_2 rods moderated to a W/U ratio of 1.0 or greater). Lower W/U values would require shifting the limiting curve to larger water separations. However, the limiting curve shown should be adequate for any normal fuel rod cluster or other moderated fissile unit.

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[1]R. D. Carter, Safe Fissile Material Spacing In Water, ARH-SA-77, Atlantic Richfield Hanford Company, 1970.